Cruise Report ZDLV-09-2022

Southern blue whiting and red cod spawning survey

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Alexander Arkhipkin	(Introduction, text of the report, biological sampling)
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Arkhipkin et al. (2022). Scientific Report, Fisheries Cruise ZDLV-09-2022. Stanley, Fisheries Department, Directorate of Natural Resources, Falkland Islands Government.

Introduction

Southern blue whiting once was one the most abundant pelagic fishes in the Patagonian Shelf and Slope. Commercial fishing for this fish in the Southwest Atlantic started in 1977 when Polish factory trawlers discovered its aggregations and caught about 2,000 t to the south and northeast of the Falkland Islands. Further exploration to identify the best seasons and areas for fishing resulted in a rapid increase in catches in the following years peaking at ~260,000 t in 1983. Targeting of dense spawning aggregations resulted in significant drop in catches to ~100,000 t per year in 1984-1985 (Csirke, 1987). Introduction of the 150 nm fishing zone and licensing regime around the Falkland Islands in 1987 decreased the effort and consequently the total catch to ~50,000 t per year. Polish and Bulgarian trawlers now licensed by the Falkland Islands Government carried on exploiting spawning and post-spawning aggregations with a maximum annual catch of 72,000 t in 1990 until it rapidly declined to ~25,000 t in 1996. Simultaneously, post-spawning aggregations of southern blue whiting were targeted by large factory trawlers in the southern part of the Patagonian Shelf in the Argentine EEZ, with the total catch peaking at 120,000 t in 1993 (Agnew, 2002; FIG, 2020).

Such a strong exploitation of the stocks caused further steady decline in catches both in Argentina and the Falkland Islands. By 1999, the total catch of southern blue whiting on the Patagonian Shelf dropped below 100,000 t, with about 1/3 of it taken in the Falkland Islands and 2/3 in Argentina. Large factory trawlers continued exploitation of the shrinking post-spawning aggregations. Recommendations by the joint UK-Argentinean South Atlantic Fisheries Commission (SAFC) to establish a total allowable catch (TAC) of 50,000 t with equal proportions to the Falkland Islands and Argentina were not followed mainly by the Argentinean fleets. The joint management of the common Patagonian stock of southern blue whiting was further aggravated by putting on hold the activities of SAFC in 2005 for political reasons. Moreover, an increased market demand in Spain for white fish products in 2005-2009 resulted in additional targeting of southern blue whiting spawning aggregations in August-October by medium-size trawlers. In 2009, the southern blue whiting stock eventually collapsed due to overfishing and disturbance of spawning aggregations with catches dropping to ~10,000 t in the Falkland Islands and ~20,000 t in Argentina (Navarro et al., 2014; FIG, 2020).

The estimated biomass in 2008 was about 26% of B_0, which was regarded at a critical level and further annual iterations taken this figure to 22% in 2009 and 13% in 2010 (FIG, 2020). In order to stop that dangerous decline in stocks further, in 2010 it was decided that a fishing ban should be imposed within the southern blue whiting spawning grounds (southwestern part of FICZ) for the whole duration of the spawning time (September – first half of October 2010) to allow the fish to spawn undisturbed. This restriction by area caused the further decrease of the total annual catch of this fish (2,000-4,000 t per year) making it economically non-viable (FIG, 2020).

Red cod is a commercial by-catch species with a trend of declining catches and abundance in the southwest Atlantic. Dense aggregations of large spawning red cod were previously found usually to the south and southwest of West Falkland Island at

depths of 170-190 m (Arkhipkin et al. 2010). Due to the declining trend in abundance, conservation measures for this species were initiated in 2009, and later expanded, leading to a complete fishing ban in their spawning grounds from the end of August to the middle of October since 2010. These conservation measures coincide in the area with the southern blue whiting conservation measure.

In August 2022, the Fisheries Department approached the single S-license holder in the Falkland Islands, Fortuna Ltd., to do an experimental survey on southern blue whiting and red cod in the closed area for fishing. After some negotiations, the company agreed to carry out a 10-day trawl survey at the end of September 2022 using their vessel and company's previous knowledge of sites where the spawning aggregations of southern blue whiting and red cod were located and fished (mainly from 2001-2007).

The present report describes the results obtained during this research survey that took place in September 2022 onboard the F/V *Petrel*.

Cruise objectives

- To study the distribution, species composition and abundance of southern blue whiting and red cod during their spawning period in the spawning area that is commonly closed to fishing in September -October of each year.
- To study the distribution and species composition of main bycatch species in the area.

Vessel

The cruise was conducted on the F/V *Petrel* (ZDLV), registered in the Falkland Islands.

Personnel and responsibilities

The following FIFD personnel participated in the cruise:

Alexander Arkhipkin	Chief Scientist
Dale Evans	Trawl survey
Michal Raczynski	Trawl Survey

Material and Methods

Cruise plan and key dates

The vessel departed from Stanley at 7 p.m. on September 20, 2022 and proceeded overnight to the first station located to the southwest of the Falkland Islands (grid square XUAH). For the next six days, the whole southern, southwestern and western areas of the closed Box (FIG, 2020) were covered with 3-5 hr trawls, deployed mainly between 250-310 m depths when targeting blue whiting, and 170-210 m when targeting red cod (Figure 1). Dense aggregations of southern blue whiting were found in the southern part of the closed Box. Bad weather with gale force south-westerly winds prevented any fishing on 26 September. Fishing was resumed on 27 September to cover the larger area in the western part of the closed Box, with one trawl performed near its western boundary. No dense aggregations of red cod were found, despite the majority of previous ‘hot spots’ being covered. The last two days of the survey were spent in the south investigating further the aggregations of southern blue whiting. The cruise was finished on October 1, 2022.

Trawling

A regular commercial bottom trawl net (~180 m door horizontal opening) was used for the survey (Figure A1, Addendum). Ground rope was equipped with rockhopper gear and the codend with additional bottom chafer to prevent damage of the net on rough grounds. One codend with 110 mm mesh size (diamond clear) with large square mesh panel (as per finfish licence regulations) was used during the whole survey.

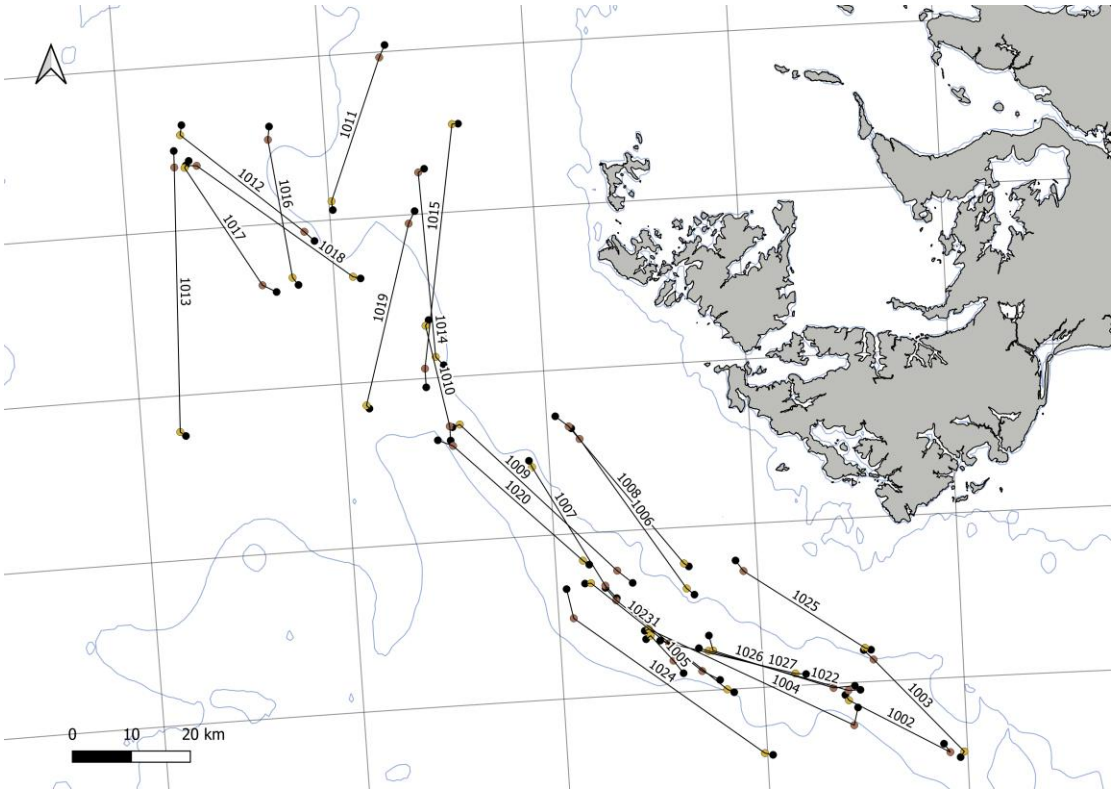

Figure 1 - Trawl tracks performed during the survey in the closed SBW Box. Station numbers are labelled above each trawl track. Black dots represent positions of shooting and hauling of the trawl, and grey/brown dots positions of the trawl on the bottom.

Sampling

Trawl stations and biological sampling

During this research cruise, designated as ZDLV-09-2022, a total of 26 trawls were conducted with corresponding station numbers ranging from 1002 to 1027. The total catch of each station was not weighed due to the commercial quantities of the main catch. For all commercial species which were retained onboard, the product weight was taken from the ship's administration and green weights of each species were calculated by applying corresponding conversion factors (2022 FIG Licence conditions). All discarded species (rock cod *Patagonotothen ramsayi* etc), were estimated by their proportion on the conveyer belt. All major commercial species (southern blue whiting, red cod and hake) were sampled (random samples of up to 100 individuals) and were measured, sexed and their maturity stages were identified as per standard biological analysis. Some bycatch species (rock cod and others, Table 2) were taken non-randomly for otolith collection. Otoliths were also taken from all toothfish caught. Some fish and squid were frozen for further analysis ashore.

Table 1 - Total catches of various species by bottom trawl during the cruise.

Species Code	*Scientific Name*	Catch (Kg)	Discard (Kg)	Percent discard
BLU	*Micromesistius australis australis*	98226.69	276.16	0.28
HAK	*Merluccius hubbsi*	65751.90	160.00	0.24
BAC	*Salilota australis*	6369.11	711.47	11.17
GRF	*Coelorinchus fasciatus*	1994.36	1994.36	100.00
DGH	*Schroederichthys bivius*	1874.10	1874.10	100.00
KIN	*Genypterus blacodes*	1289.90	5.00	0.39
PAR	*Patagonotothen ramsayi*	615.55	611.65	99.37
RFL	*Dipturus chilensis*	503.10	105.30	20.93
LOL	*Doryteuthis gahi*	407.12	51.00	12.53
TOO	*Dissostichus eleginoides*	296.81	84.76	28.56
RBR	*Bathyraja brachyurops*	281.45	127.15	45.18
CGO	*Cottoperca gobio*	250.60	250.60	100.00
THO	*Thouarella*	115.54	115.54	100.00
WHI	*Macruronus magellanicus*	92.78	92.78	100.00
SPN	Porifera	87.00	87.00	100.00
RGR	*Bathyraja griseocauda*	77.32	12.20	15.78
MUL	*Eleginops maclovinus*	38.07	5.93	15.58
RSC	*Bathyraja scaphiops*	22.60	0.00	0.00
NEM	*Psychrolutes marmoratus*	19.52	19.52	100.00
RMU	*Bathyraja multispinis*	19.50	0.00	0.00
RBZ	*Bathyraja cousseauae*	16.70	3.70	22.16
PYM	*Notophycis marginata*	16.63	16.63	100.00
RMC	*Bathyraja macloviana*	16.10	16.10	100.00
ING	*Onykia ingens*	14.45	14.45	100.00
GOC	*Gorgonocephalus chilensis*	13.68	13.68	100.00
POA	*Glabraster Antarctica*	13.68	13.68	100.00
RAL	*Bathyraja albomaculata*	13.50	3.00	22.22
ERR	*Errina antarctica*	10.78	3.26	30.24

Species Code	*Scientific Name*	Catch (Kg)	Discard (Kg)	Percent discard
RMG	*Bahyraja magellanica*	10.60	10.60	100.00
MED	Medusa	10.00	10.00	100.00
MIR	*Plumarella (Verticillata) castellviae*	8.40	8.40	100.00
ASA	*Astrotoma agassizii*	5.87	5.87	100.00
RDO	*Amblyraja doellojuradoi*	5.60	5.60	100.00
ZYP	*Zygochlamys patagonica*	5.35	5.35	100.00
STA	*Sterechinus agassizii*	5.06	5.06	100.00
GRC	*Macrourus carinatus*	4.00	4.00	100.00
DGS	*Squalus acanthias*	3.00	3.00	100.00
PAT	*Merluccius australis*	3.00	0.00	0.00
ANM	Actiniaria	2.81	2.81	100.00
LIS	*Lithodes santolla*	2.69	0.33	12.27
HYD	Hydrozoan	2.05	2.05	100.00
BRY	Bryozoan	2.00	2.00	100.00
FUM	*Fusitriton m. magellanicus*	1.69	1.69	100.00
CAZ	*Calyptraster*	1.63	1.63	100.00
MLA	*Muusoctopus Longibranchus akambei*	1.40	1.40	100.00
RPX	*Psammobatis* sp.	1.22	1.22	100.00
ILF	*luocoetes fimbriatus*	1.20	1.20	100.00
RED	*Sebastes oculatus*	1.17	1.15	98.29
COL	*Cosmasterias lurida*	0.91	0.91	100.00
AST	*Asteroidea*	0.91	0.91	100.00
CAS	*Campylonotus semistriatus*	0.75	0.75	100.00
EUO	*Eurypodius longirostris*	0.69	0.69	100.00
LOS	*Lophaster stellans*	0.69	0.69	100.00
CEX	*Ceramaster patagonicus*	0.69	0.69	100.00
BAO	*Bathybiaster loripes*	0.56	0.56	100.00
OCM	*Enteroctopus megalocyathus*	0.50	0.50	100.00
BAL	*Americominella duartei*	0.49	0.49	100.00
OPV	*Ophiacantha vivipara*	0.39	0.39	100.00
COT	*Cottunculus granulosus*	0.38	0.38	100.00
WRM	Worms	0.37	0.37	100.00
CRY	*Crossaster* sp.	0.34	0.34	100.00
OPL	*Ophiura lymani*	0.28	0.28	100.00
CYX	*Cycethra* sp.	0.28	0.28	100.00
SQT	Tunicata	0.25	0.25	100.00
AUC	*Austrocidaris canaliculata*	0.24	0.24	100.00
EGG	Eggs	0.23	0.23	100.00
ADA	*Adelomelon ancilla*	0.22	0.22	100.00
ODM	*Odontocymbiola magellanica*	0.22	0.22	100.00

Species Code	*Scientific Name*	Catch (Kg)	Discard (Kg)	Percent discard
SOR	*Solaster regularis*	0.22	0.22	100.00
PRX	Paragorgia	0.20	0.20	100.00
HEX	*Henricia* sp.	0.17	0.17	100.00
PES	*Peltarion spinosulum*	0.14	0.14	100.00
CTA	*Ctenodiscus australis*	0.13	0.13	100.00
NOW	*Paranotothenia magellanica*	0.12	0.00	0.00
PYX	Pycnogonida	0.09	0.09	100.00
ODP	*Odontaster penicillatus*	0.06	0.06	100.00
SAR	*Sprattus fuegensis*	0.06	0.06	100.00
FLX	*Flabellum sp.*	0.06	0.06	100.00
SUN	*Labidiaster radiosus*	0.04	0.04	100.00
DIA	*Diaulula* spp	0.03	0.03	100.00
UCH	Urchin	0.03	0.03	100.00
ALC	Alcyoniina	0.02	0.02	100.00
PEN	Pennatulacea	0.02	0.02	100.00
CAM	*Cataetyx messieri*	0.02	0.00	0.00
LIR	*Limopsis marionensis*	0.02	0.02	100.00
ASF	*Astrina fimbrata*	0.01	0.01	100.00
BER	*Berthella* sp.	0.01	0.01	100.00
LAP	*Lamellaria patagonica*	0.01	0.01	100.00
LIG	*Libidoclaea granaria*	0.01	0.01	100.00
PLU	Primnoidae	0.01	0.01	100.00
SET	Aglaopheniidae	0.01	0.01	100.00
BRM	*Brucerolis macdonnellae*	0.01	0.01	100.00
NUD	Nudibranch	0.01	0.01	100.00
ISO	Isopoda	0.00	0.00	100.00
OPS	*Ophiactis asperula*	0.00	0.00	100.00
OIB	*Oidiphorus brevis*	0.00	0.00	100.00

Table 2 – Number of otoliths collected during the research cruise by species.

Species Code	Scientific name	F	M	Total
BAC	*Salilota australis*	23	7	30
BLU	*Micromesistius australis australis*	32	24	56
CGO	*Cottoperca gobio*		1	1
COT	*Cottunculus granulosus*	1	2	3
HAK	*Merluccius hubbsi*	43	1	44
ILF	*Iluocoetes fimbriatus*		1	1
KIN	*Genypterus blacodes*	9	2	11
MUL	*Eleginops maclovinus*	4	5	9
NEM	*Psychrolutes marmoratus*	2		2
PAR	*Patagonotothen ramsayi*	11	3	14
PYM	*Notophycis marginata*	1	1	2
RED	*Sebastes oculatus*	1	4	5
SAR	*Sprattus fuegensis*		1	1
TOO	*Dissostichus eleginoides*	81	53	134
WHI	*Macruronus magellanicus*	3	1	4
Total				**318**

RESULTS

Southern blue whiting Micromesistius australis australis

Southern blue whiting was found to create dense spawning aggregations in their common spawning grounds in the southern and western parts of the closed Box at depths 270-310 m. The highest densities of spawning schools were encountered to the south of West Falkland (Figure 2), with total catches over 32 t per trawl (CPUE >40 t per hour) (Figure 3). The spawning aggregations were 60-70 m high, they stayed over the bottom during the daytime, but then dispersed throughout water column at night. Small quantities of mature fish were also present in the western part of the Box (up to 1 t per trawl).

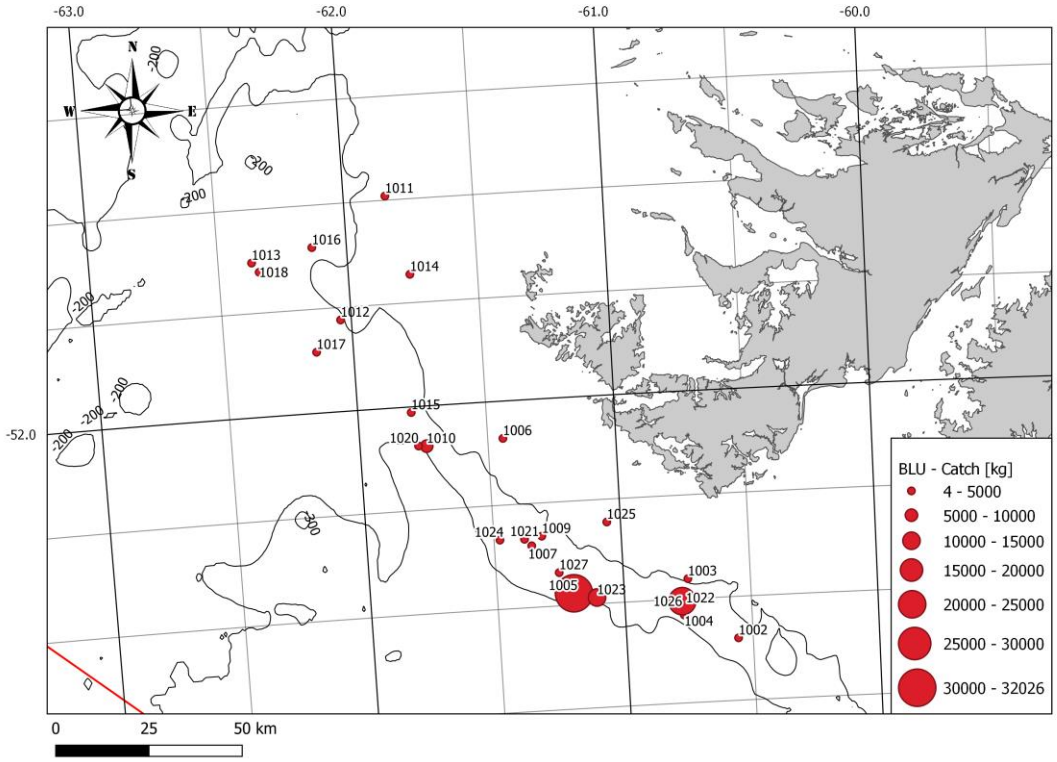

Figure 2. Catches (kg per trawl) of southern blue whiting in the area studied.

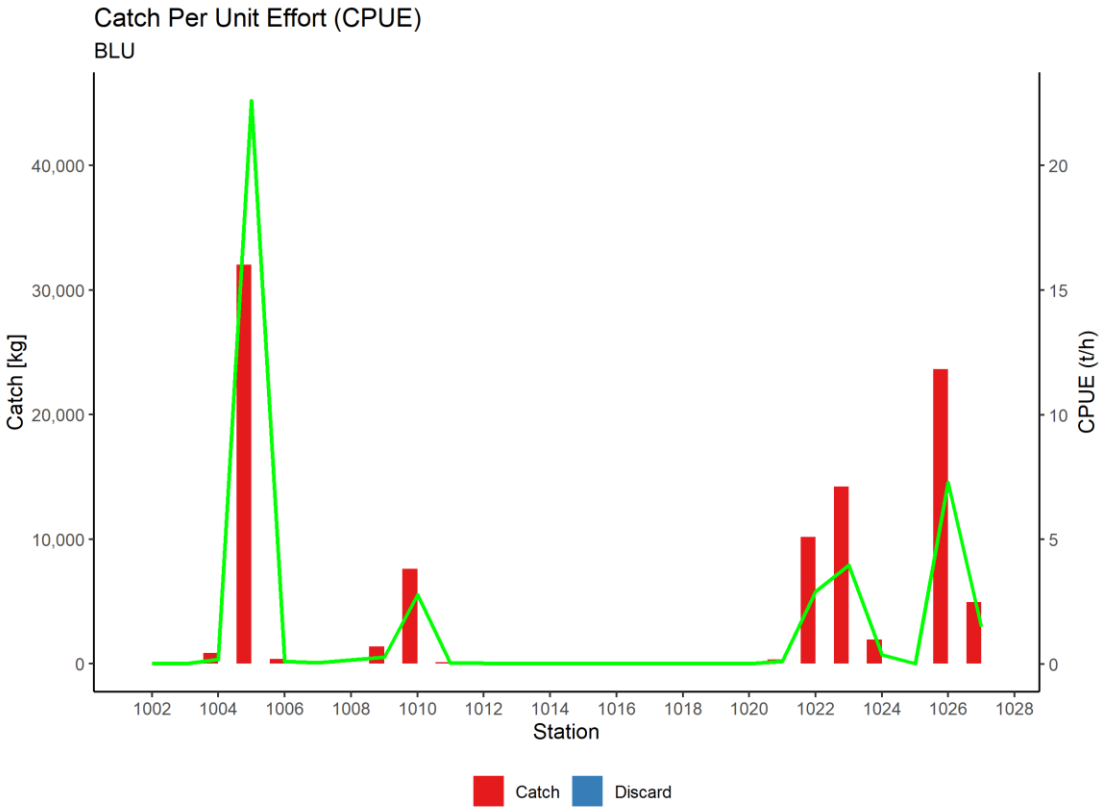

Figure 3. Catches (kg per trawl, red bars) and CPUEs (t per hr, green line) of southern blue whiting by station in the area studied.

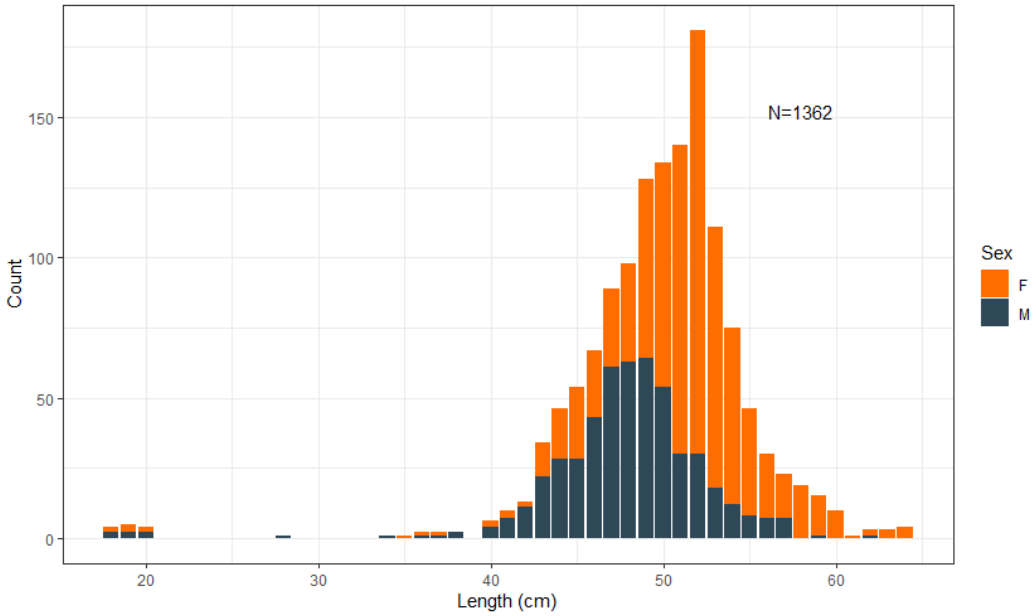

Figure 4. Size composition of southern blue whiting by sex (orange, females and blue, males) during the research cruise.

Distribution of sizes was unimodal in both sexes. Males were smaller than females, with modal lengths of 47-49 cm total length (TL) and 52 cm TL, respectively (Figure 4). Some small immature fish (18-20 cm TL) appeared in the catch from the mesh of the trawl. Sex ratios were with a prevalence of females, 1.66:1.

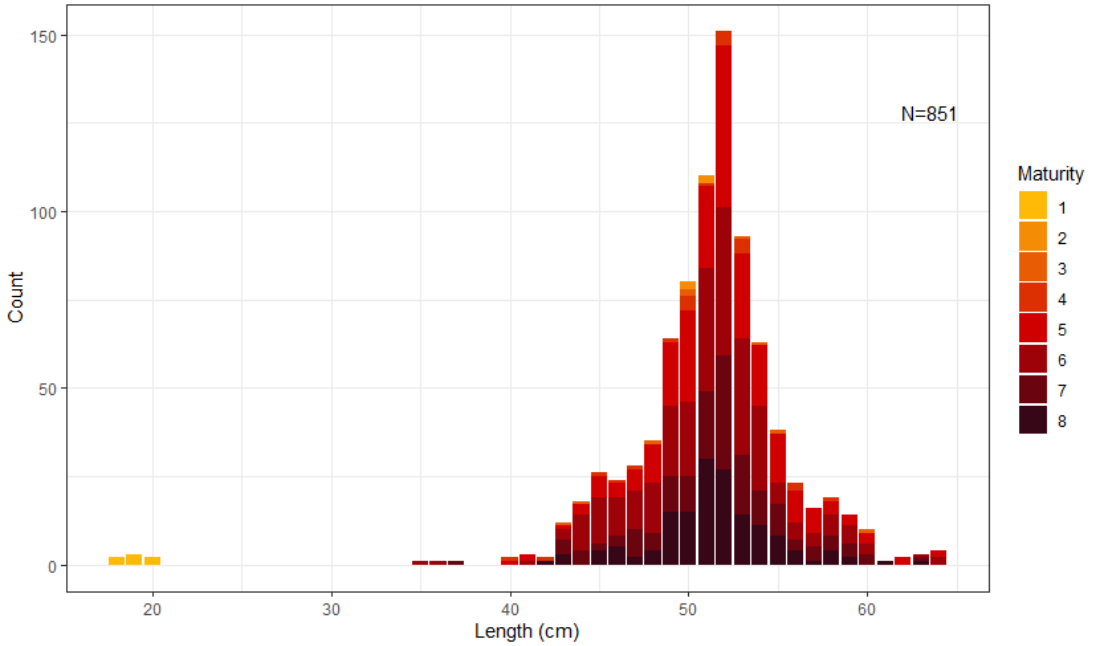

Figure 5. Size composition of females of southern blue whiting by maturity stage during the research cruise.

Aggregations were composed of mature, spawning and postspawning females (Figure 5).

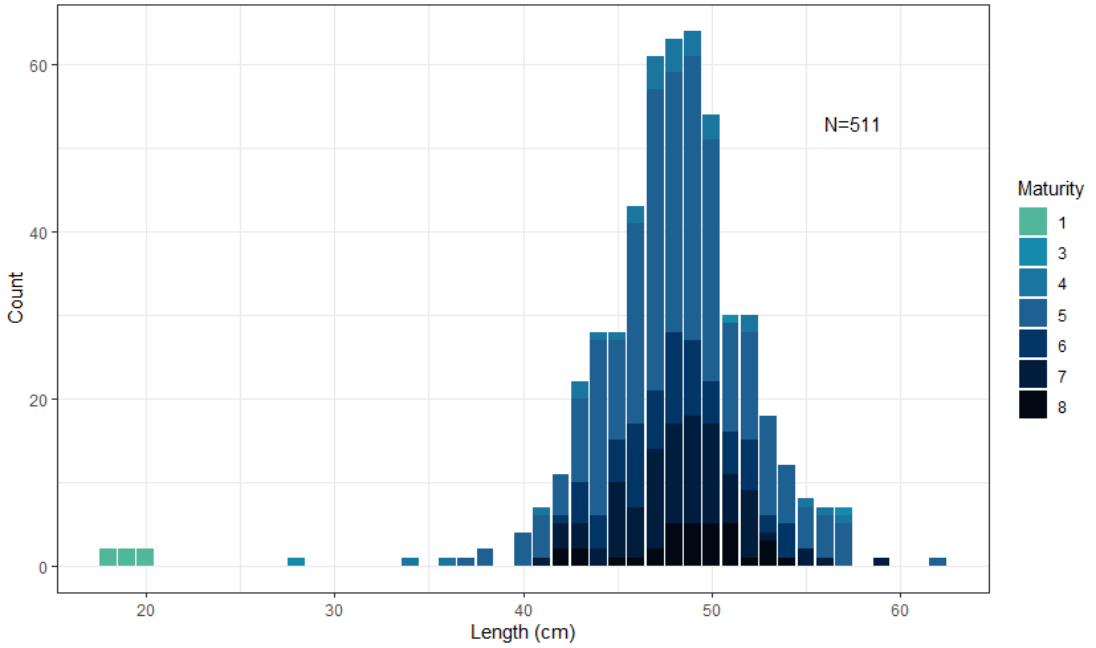

Figure 6. Size composition of males of southern blue whiting by maturity stage during the research cruise.

Males were also mature, with the majority of them being at stages 5 and 7 (Figure 6).

Parasites

At several stations, fish were also checked for the presence of *Kudoa* sp. parasites in the flesh. For this, 20 fish were taken randomly from the catch and filleted from each of these three stations, and a number of parasites in the flesh was noted. The incidence of infection was low varying from 1.4 to 3.1 parasites per fish (Table 3).

Table 3 – Number of parasites *Kudoa* sp. in the flesh of southern blue whiting during the research cruise.

	St. 1008	St. 1022	St. 1026
Sample 1	0	5	0
Sample 2	0	3	2
Sample 3	2	1	0
Sample 4	3	0	1
Sample 5	1	0	0
Sample 6	1	0	0
Sample 7	0	0	1
Sample 8	2	2	0
Sample 9	0	2	0
Sample 10	3	0	3
Sample 11	2	2	0
Sample 12	0	3	1
Sample 13	1	3	0
Sample 14	1	2	0
Sample 15	2	6	3
Sample 16	0	0	0
Sample 17	1	0	0
Sample 18	4	0	0
Sample 19	0	0	0
Sample 20	2	1	0
Sample 21	1	0	0
Sample 22	3	4	4
Sample 23	2	2	0
Sample 24	0	1	0
Sample 25	1	2	0
Sample 26	0	1	0
Sample 27	0	2	1
Sample 28	0	2	5
Sample 29	1	6	1
Sample 30	1	0	0
Sample 31	0	2	0
Sample 32	0	0	0
Sample 33	1	2	0
Sample 34	0	0	1
Sample 35	0	4	3

	St. 1008	St. 1022	St. 1026
Sample 36	0	1	1
Sample 37	1	2	0
Sample 38	0	0	1
Sample 39	0	0	0
Sample 40	0	1	0
TOTAL	36	62	28
Average per fillet	0.9	1.55	0.7
Average per fish	1.8	3.1	1.4

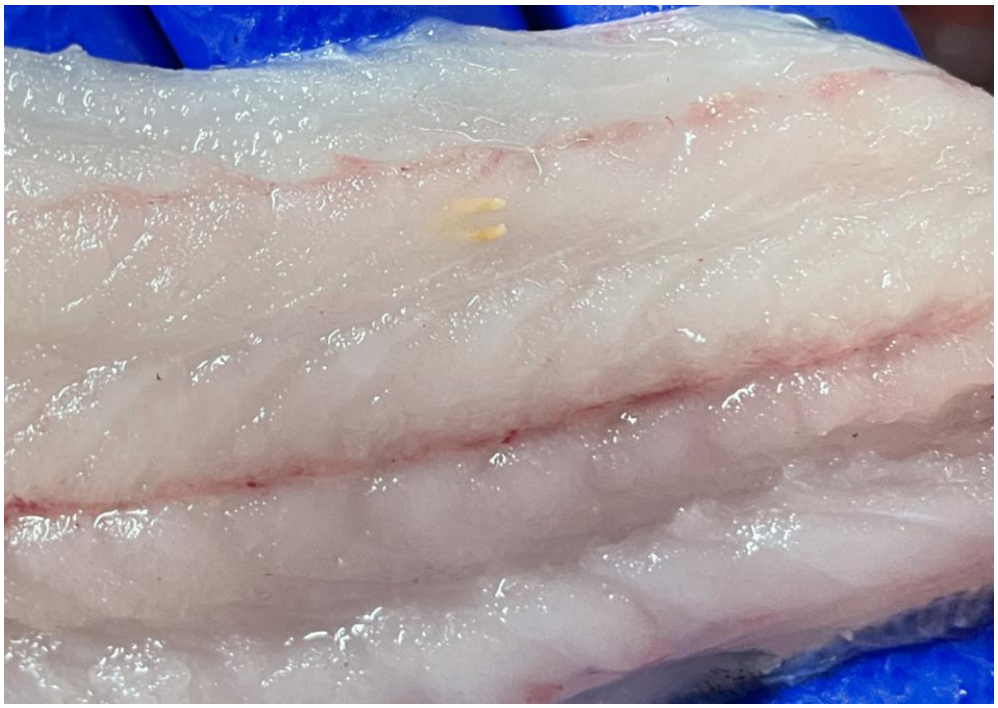

Figure 7. Embedded parasite *Kudoa* sp. in the flesh of southern blue whiting.

Spawning period

Continuous sampling of mature and spawning fish enabled to identify the dates of the spawning period (prevalence of Maturity Stage 6) of southern blue whiting in the area studied. It started on 23 September and finished on 28 September 2022 (Figure 8). This period corresponded to the darkest nights around the New Moon (Figure 9).

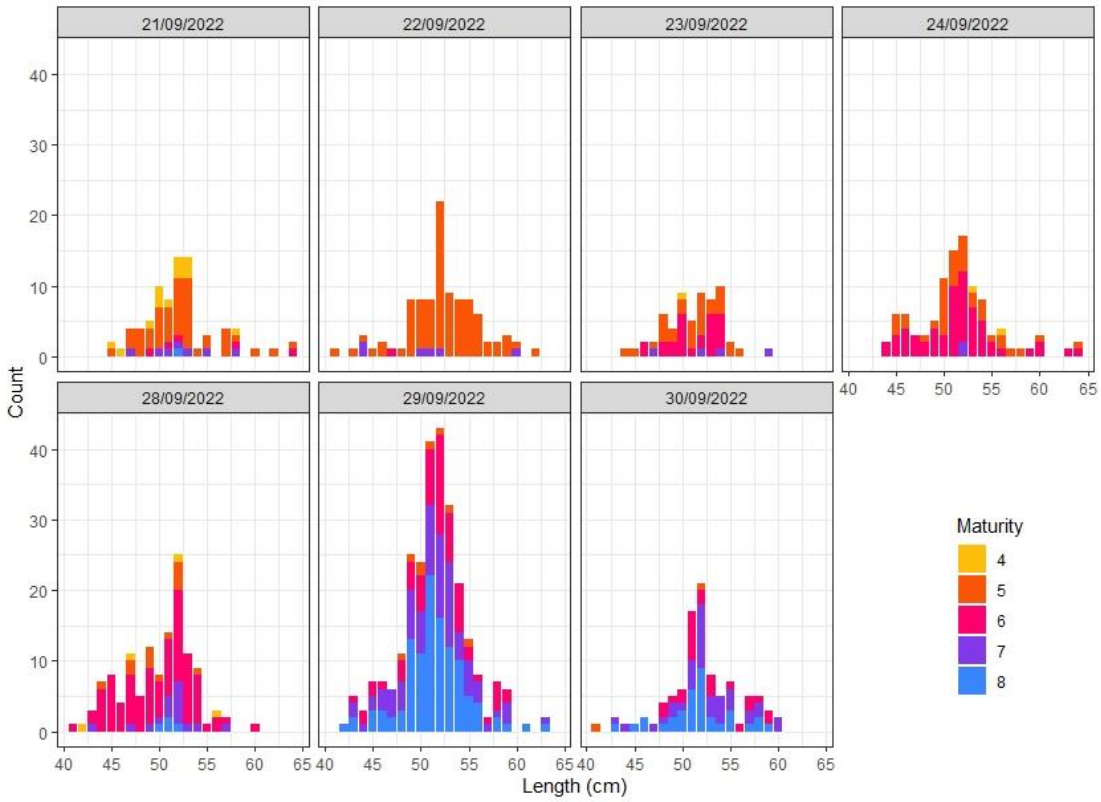

Figure 8. Maturity stages of southern blue whiting females by date.

Figure 9. Moon phases at the end of September 2022.

Red cod Salilota australis

Despite extensive trawling and acoustic surveying at depths known for red cod habitat, we did not encounter any significant aggregations of spawning fish. Largest catches did not exceed 2 t per trawl, and were observed deeper than usual – at depths 260-290 m (Figure 10). The highest densities of spawning schools were encountered to the south of West Falkland, with CPUE >0.40 t per hour) (Figure 11). Small aggregations of spawning fish were also encountered to the west (maximum 0.2 t per hour) and southwest of West Falkland (maximum 0.3 t per hour). Overall, dense spawning aggregations of red cod were not found, especially in quantities that were registered 15-20 years ago.

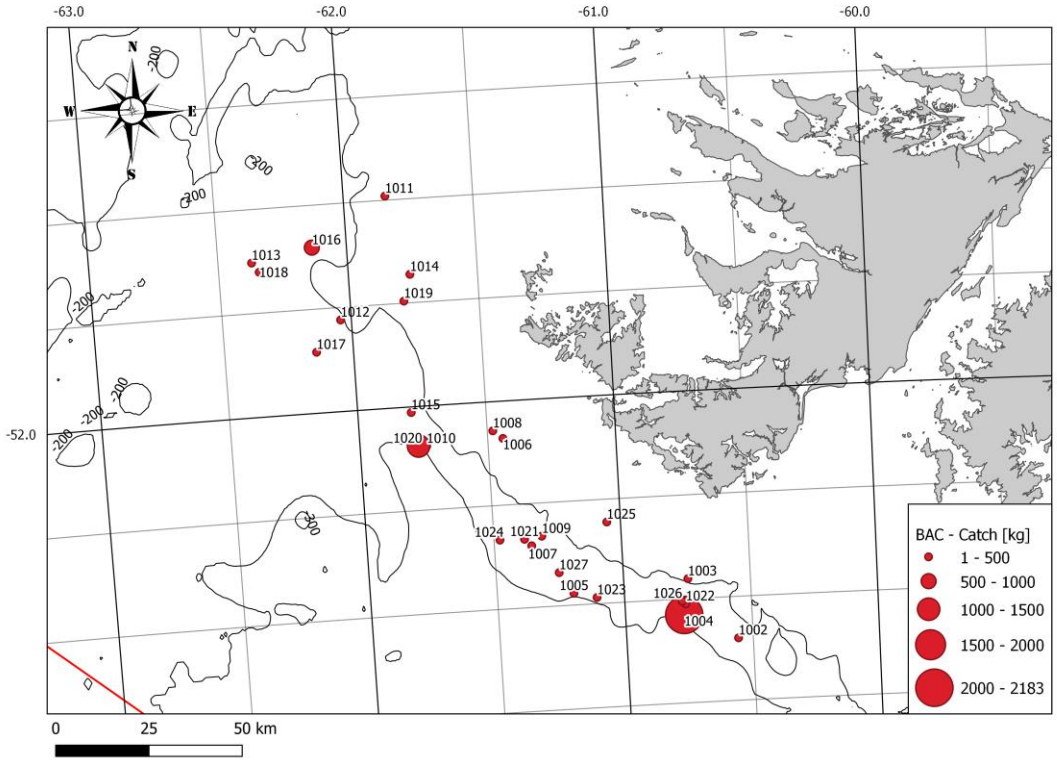

Figure 10. Catches (kg per trawl) of red cod in the area studied.

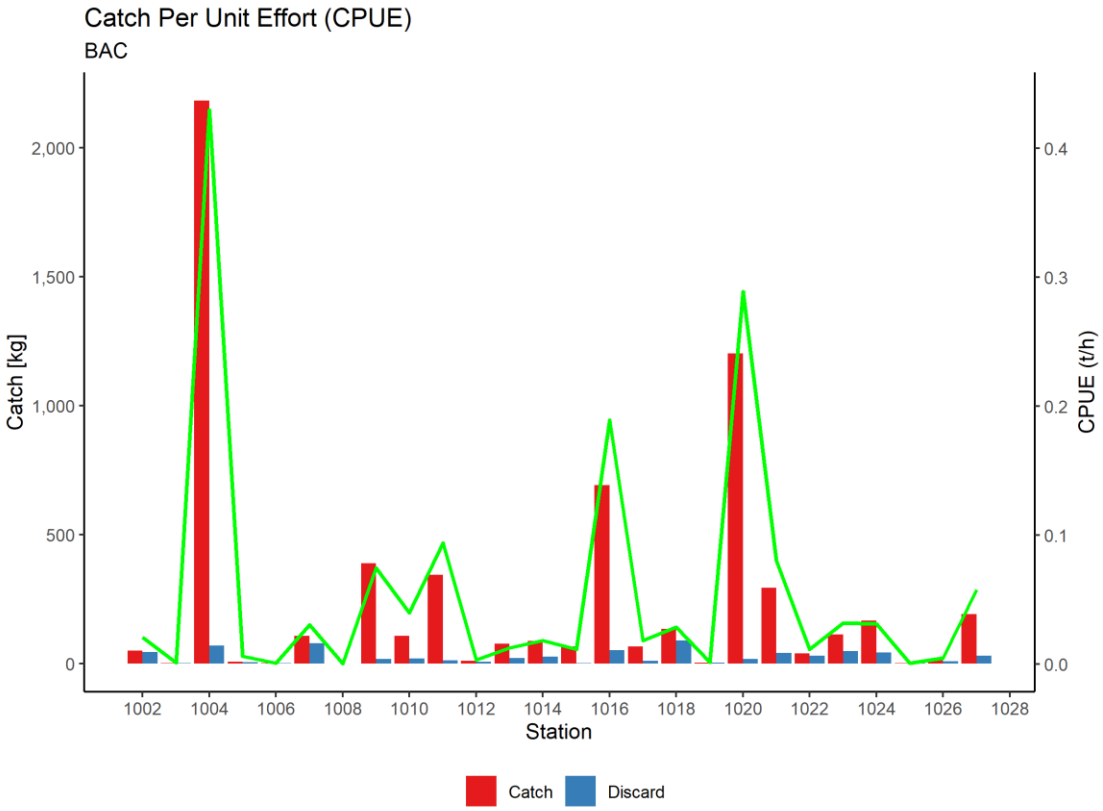

Figure 11. Catches (kg per trawl, red bars) and CPUEs (t per hr, green line) of red cod by station in the area studied.

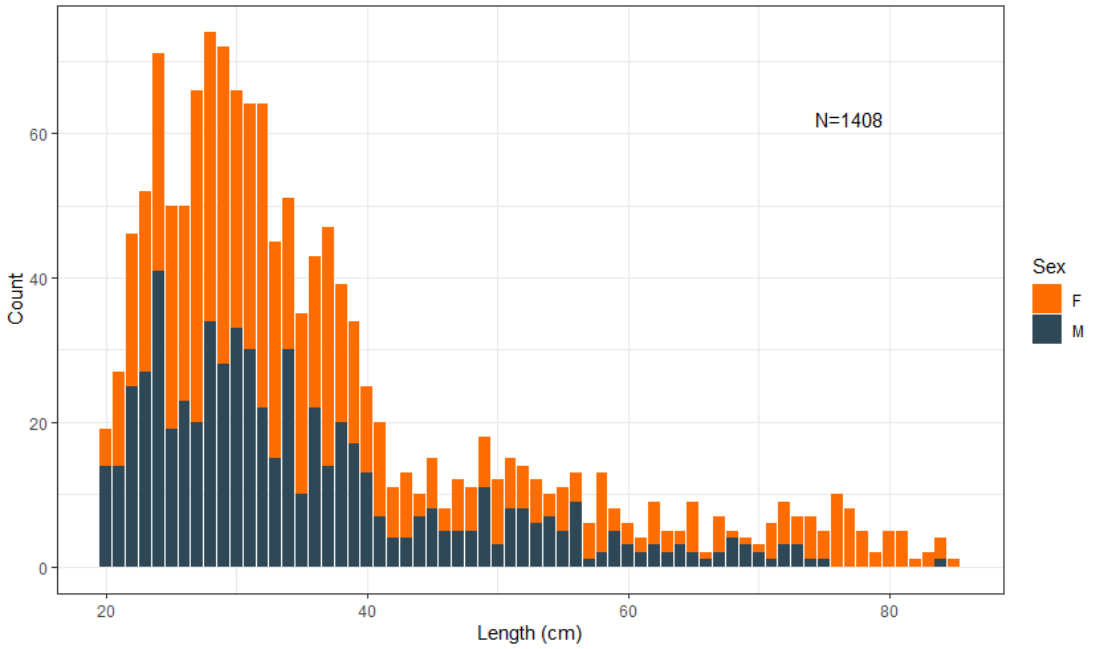

Figure 12. Size composition of red cod by sex (orange, females and blue, males) during the research cruise.

Despite relatively small quantities, the distribution of sizes of red cod was 'healthy' with recruitment of 30-35 cm being the most abundant. Size range was quite impressive, from young fish of 20 cm TL to mature adults of 85 cm TL (Figure 12). Sex ratios were with a slight prevalence of females, 1.27:1.

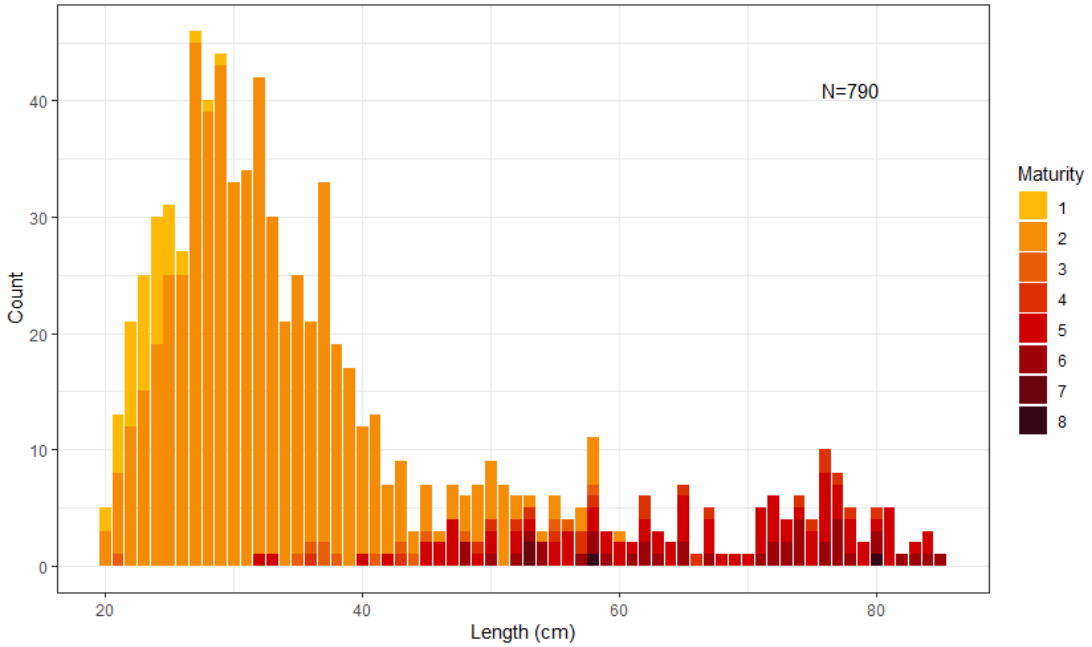

Figure 13. Size composition of females of red cod by maturity stage during the research cruise.

The majority of female recruitment was immature, with first mature females appearing at relatively small sizes of 32-33 cm TL. All large females >60 cm TL were mature, with some of them being spawning and spent after the spawn (Figure 13).

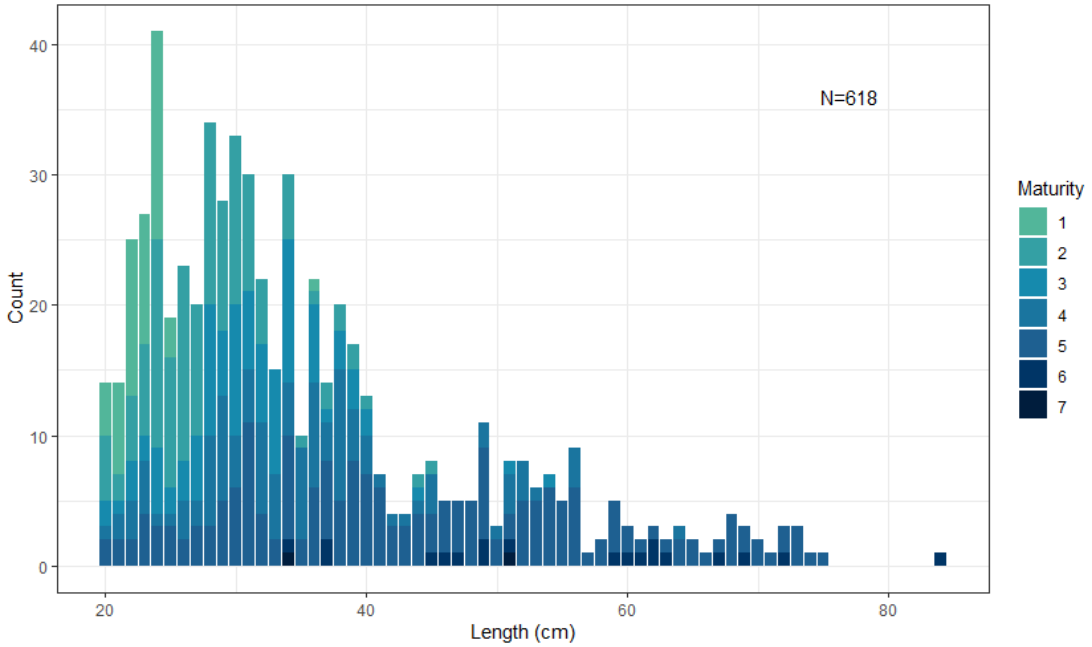

Figure 14. Size composition of males of red cod by maturity stage during the research cruise.

Males started to mature (stage 3) being as small as 20-22 cm TL. After 40 cm TL, the great majority of fish were at various stages of maturation (Figure 14).

Common hake *Merluccius hubbsi*

Common hake was the second most abundant commercial fish during the research cruise, with the total catch >65 t (Table 1). At this time of the year, hakes migrate from their southernmost feeding grounds at depths >270 m to the south of the Falkland Islands northwards, negotiating the Islands both in the west and east. Obviously, only western part of their migration was registered during the research cruise. In the last ten days of September, hakes usually pass southwestern part of FICZ and move across the western part of the fishing zone at depths >200 m. The aggregations were not dense, but frequent. The highest densities of hake were registered at the station 1007 (>3 t per hour) in the southwest, with dense aggregations of fish being also observed to the west of the Falkland Islands (Stations 1013 and 1018) with CPUE 2-2.5 t per hour. At depths shallower than 200 m, quantities of migrating hakes were small (Figure 15, 16).

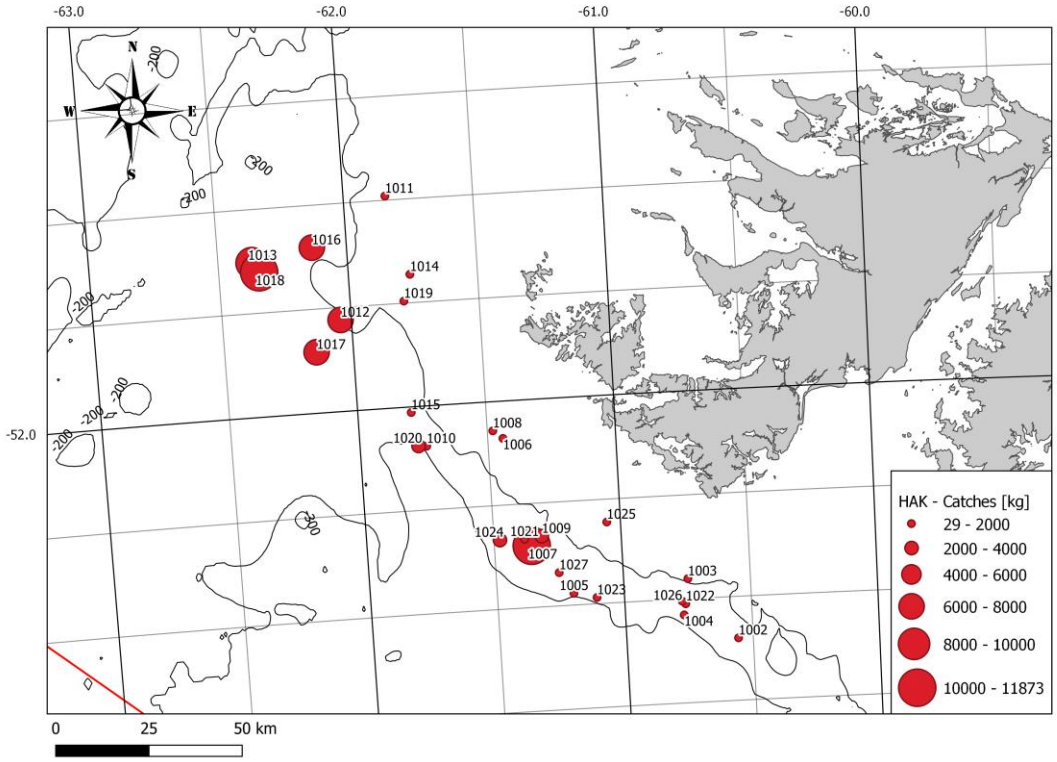

Figure 15. Catches (kg per trawl) of common hake in the area studied.

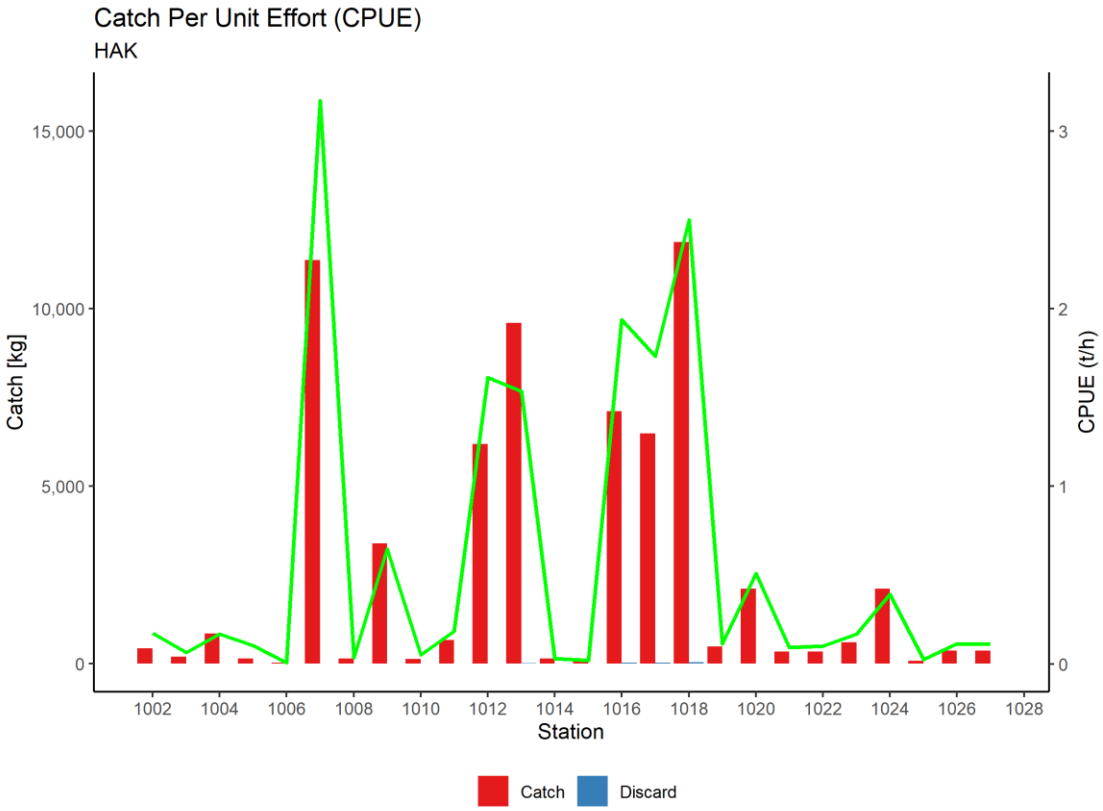

Figure 16. Catches (kg per trawl, red bars) and CPUEs (t per hr, green line) of common hake by station in the area studied.

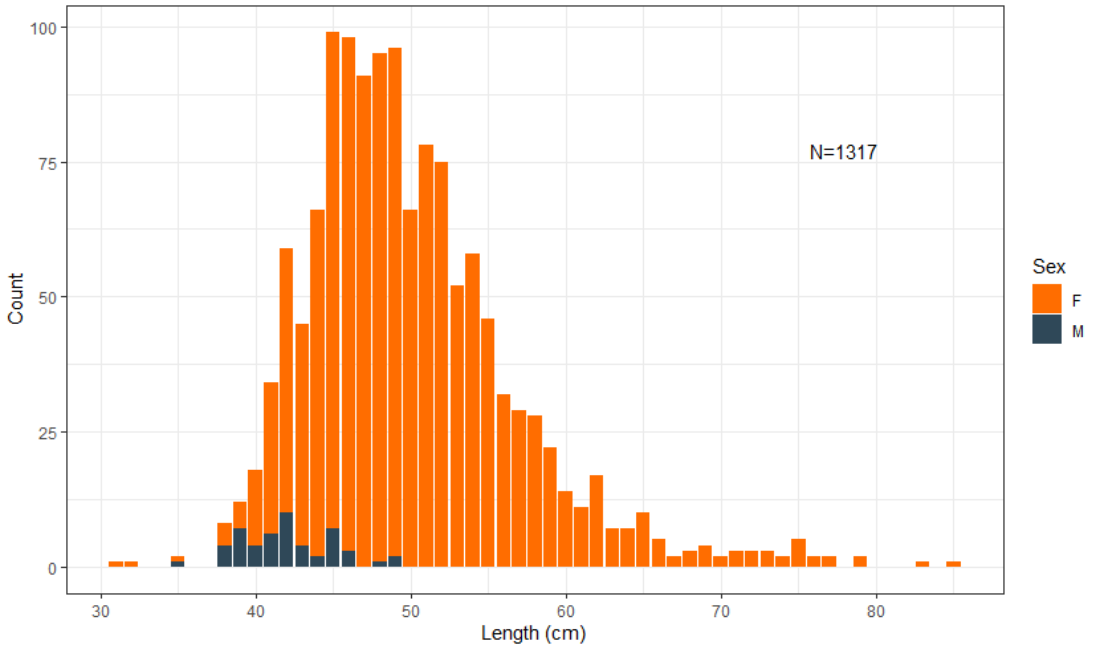

Figure 17. Size composition of common hake by sex (orange, females and blue, males) during the research cruise.

Distribution of sizes of hakes was broadly unimodal, ranging between 45 and 49 cm TL. Length frequency was right skewed with the largest fish measured at 87 cm TL (Figure 17). The great majority of hake were females, with sex ratio being with massive prevalence of females, 24.8:1.

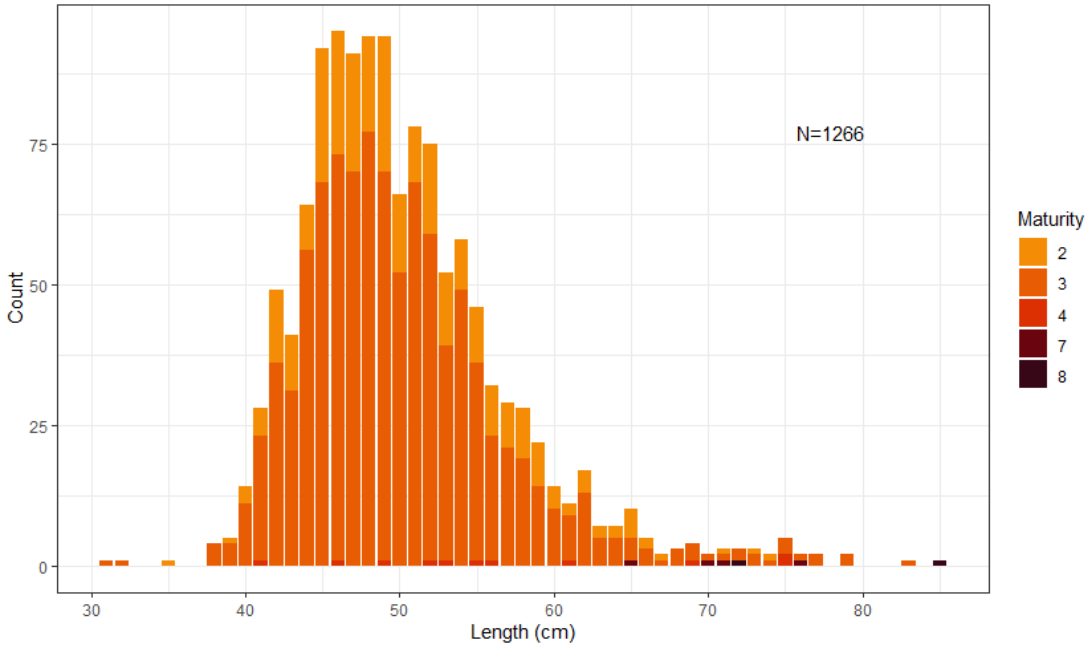

Figure 18. Size composition of females of common hake by maturity stage during the research cruise.

As expected (Arkhipkin et al., 2012), the majority of females started their maturation being at maturity stage 3. Several females were in more advanced maturity Stage 4 (Figure 18).

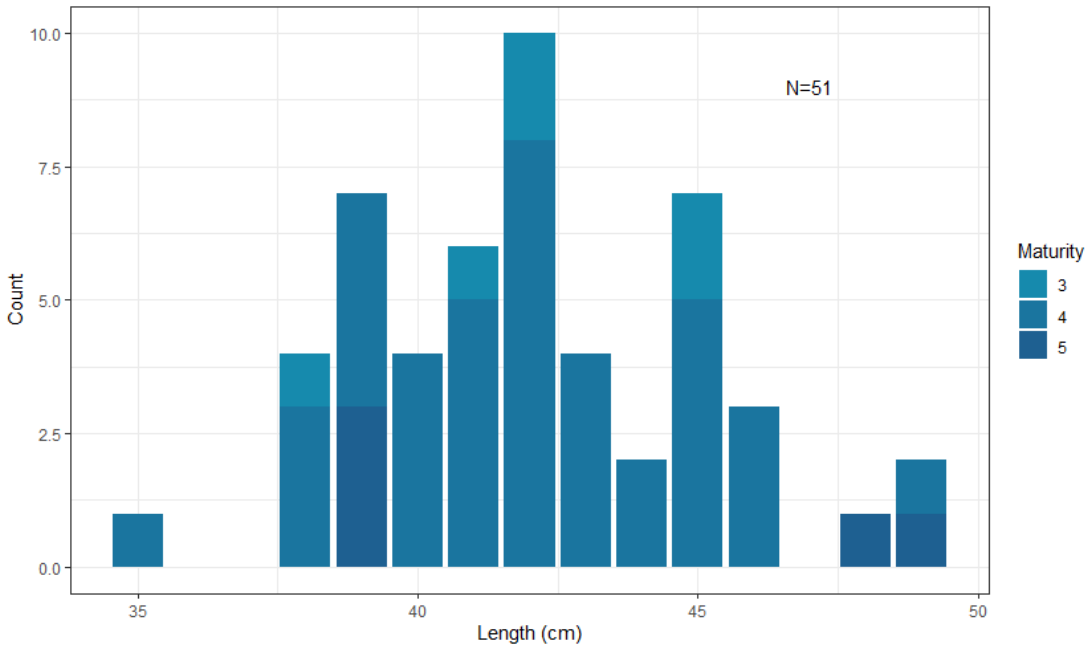

Figure 19. Size composition of males of common hake by maturity stage during the research cruise.

The majority of males were at advanced maturation (Stage 4), with some being mature at Stage 5 (Figure 19).

Biomass estimate of southern blue whiting

Biomass of southern blue whiting was estimated using the swept-area method, calculating catch density per trawl by triangulating the distance between trawl doors (174-226 m) to the horizontal opening of the net. Catch densities per trawl were then extrapolated to a survey area bounded by the 150 m and 300 m isobaths, longitudes 63°W and 60°W, and latitude 51.5°N to the north (Figure 18), using inverse distance weighting. The biomass estimate of southern blue whiting was 25467.9 t within this bounded survey area of 12980.3 km^2. This biomass estimate should, however, be considered an approximation close to the lower limit, as the survey bottom-trawl net, reaching a maximum vertical opening of ~4.5 m, may not have captured the full water column distribution of southern blue whiting aggregations that can be 10s of metres high. The density distribution was dominated by one very high catch trawl of the Station 1005 located to the south of the closed Box (Figure 20). That one very high-density location was notably close (1.65 km distance) to the highest density location identified during the September 2019 survey for southern blue whiting (Winter and Busbridge 2020).

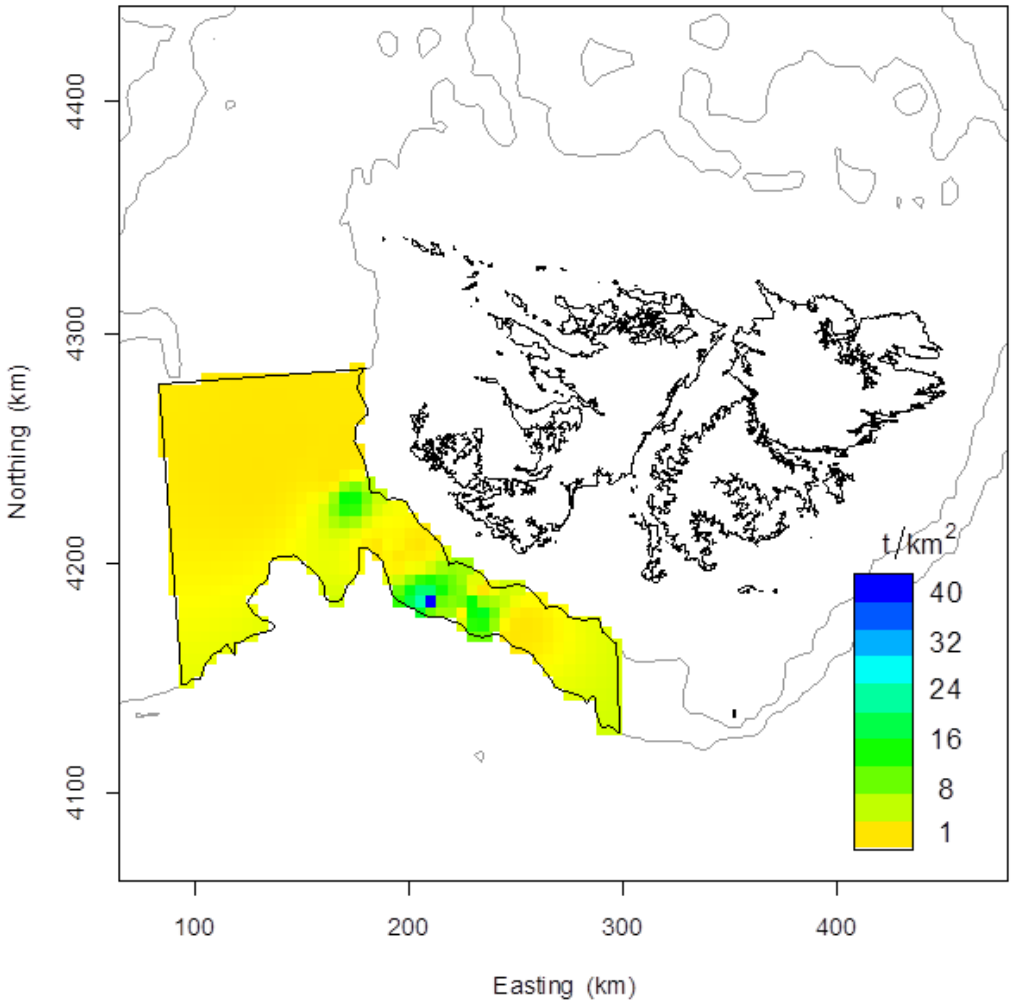

Figure 20. Biomass densities (in t per square km) of southern blue whiting in the area studied.

Conclusions

1. The commercial stock of southern blue whiting is on the way of its recovery. About 25,000 t of fish was estimated to be in their spawning grounds to the south and southwest of the closed Box.

2. The sizes of southern blue whiting (modal length of 52 cm TL) are close to common commercial size that was observed during its abundant commercial fishery 20-25 years ago.

3. The incidence of parasite infection of the flesh in southern blue whiting is relatively low (1.4-3.1 parasites per fish), which is probably related to the recent bottleneck in population abundance.

4. Densities of spawning schools of red cod are very low, with maximum CPUEs of 0.4 t per hour. Stock of this fish definitely decreased around the Falkland Islands. On the positive side, the recruitment is quite abundant, that resulted in 'healthy' looking length structure of the population. The fish did not occur in their common spawning grounds at depths <200 m, but deeper at 250-290 m.

5. The abundance of hake (2-3 t per hour) was not as big as in the northern part of FICZ (5-6 t per hour). However, the fish was significantly larger (modal lengths 45-50 cm TL) comparing to 40-45 cm TL in the north, due to only larger females reaching their southernmost feeding areas to the south of the Falkland Islands.

Recommendations

1. The southern blue whiting biomass estimate suggests that a one-time commercial quota of up to 3,800 – 4,000 t could presently be allowed, subject to review of the stock thereafter. A more comprehensive area survey for southern blue whiting, with semi-pelagic trawl gear, should also be undertaken to evaluate the potential for resuming regular fishing of this species.

2. Low biomass of spawning red cod is concerning. One of the recommendations could be an expansion of the closed area to the west and south to the depths of 350 m in September - first half of October, to allow the fish to spawn undisturbed by continuous targeting hake by the finfish fleet outside the closed area.

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ADDENDUM

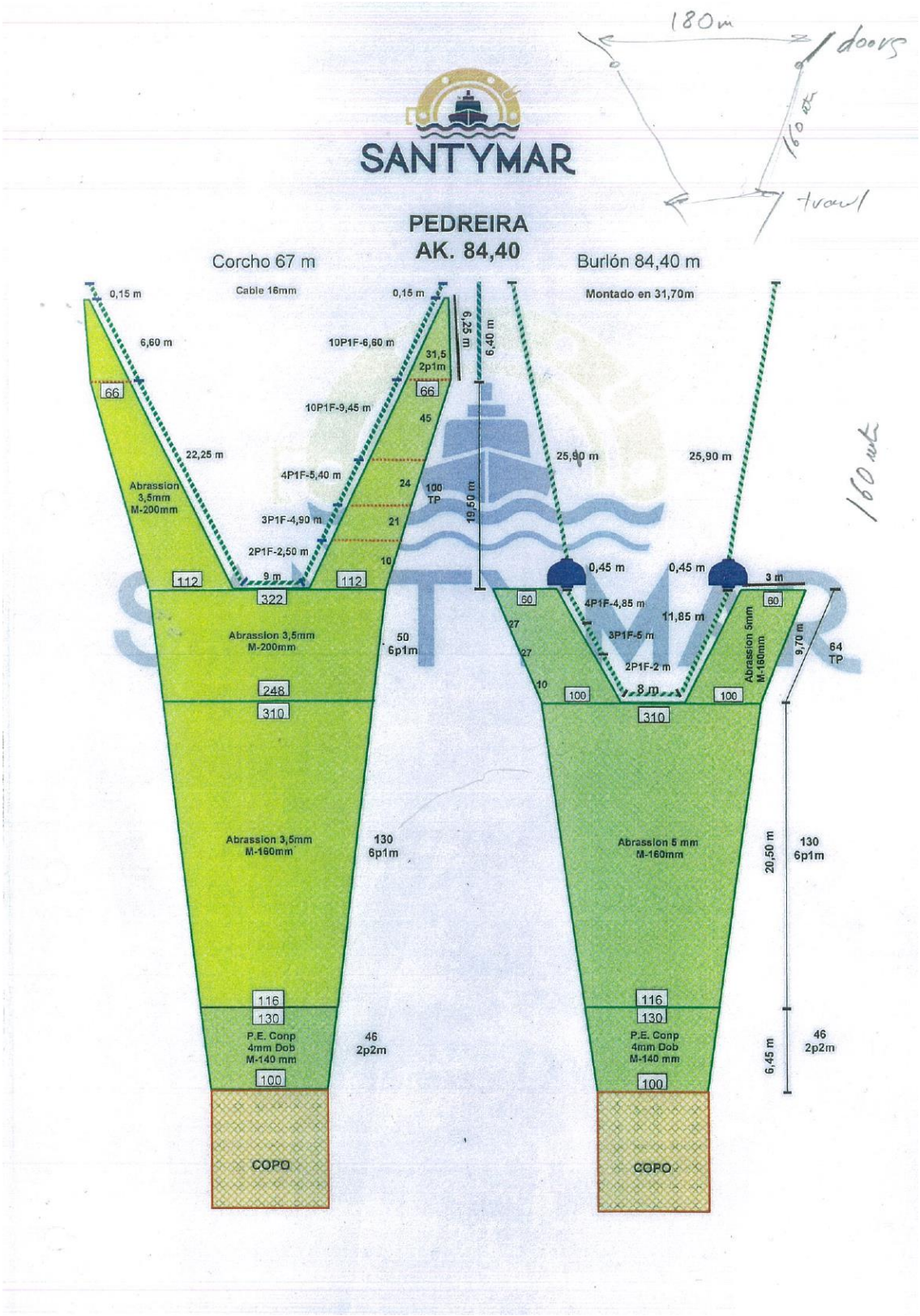

Figure A1. Schematic and measurements of the bottom trawl used during the research survey.